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Temperature models of technological processes in the production of ceramic building materials

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ABSTRACT: In the production of ceramic building materials, the firing process is one of the most important processes in its production. This is due to the fact that in this process, ceramic products take quality parameters. Proper coordination of the combustion phase depends, first of all, on the effective use of the distribution of thermal energy. The article describes the factors that make up the temperature models of a tunnel kiln and a brick dryer in rotating furnaces. A heat equation is considered for tunnel kilns for drying and baking ceramic building materials consisting of the heat transfer equation and the heat consumption equation. A heat treatment model was created for one hour of working time in a rotary kiln as a result of heat transfer and analysis of the heat consumption equations. From the obtained models it is possible to find gas consumption for an hour in the furnace for efficient baking of ceramic building materials.

KEY WORDS: Temperature, ceramics, firing, fuel, soil, water volume, gas, combustion, physical heat.

I.INTRODUCTION

Increasing the pace of construction and competition between manufacturers of building materials in the market causes the need to increase the number and improve the quality of construction bricks. This task can be solved by improving the control systems of technological processes, in particular roasting, which is at the end of the production cycle of brick production. It is during the firing process that the properties of the products that define the concept of "quality" are formed. It includes both measurable mechanical and hydrophysical indicators (strength, frost resistance and water absorption), and visual defects (cracks, fusion, burnt). Firing should be considered as a set of heat and mass transfer processes, which are accompanied by phase and chemical transformations of raw materials.

This process, which is carried out mainly in tunnel furnaces, is characterized by a temperature distribution of the gaseous medium. . Proper coordination of the combustion phase depends, first of all, on the effective use of the distribution of thermal energy.

II. TEMPERATURE MODELS OF TECHNOLOGICAL PROCESSES

Equation of heat tunnel kilns for drying and baking ceramic building materials consists of the following:
Heat transfer equations:

- Through the process of burning fuel.
- Physical heat of fuel.
- Heat input with raw materials.
- The amount of physical heat brought by the air in the combustion process.
- The physical heat of air in the furnace head due to air transfer due to the lack of a tight closure of the chamber of the furnace.
- The amount of physical heat brought into the furnace with secondary air.

The equation of heat consumption:

- Heat consumption to extract moisture.
- Heat consumption in chemical reactions.

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- Loss of heat due to the exit of the finished product from the furnace.
- Amount of heat lost to the environment.
- Amount of heat lost by the flue gas.
- The amount of heat loss due to incomplete ignition of the fuel.

Soil reserves are used for the production of bricks. The composition of the bricks is as follows [1]:

$i0_2$	1_20_3	e_20_3	0_2	gO	aO	a_20	$_20$	A nd other mixtures	otal:
4.37	1.96	.6	.43	.08	1.4	.71	.25	1 2.2	00%

The temperature of the brick should not exceed 1100 °C. In the case of the use of natural gas as fuel, the composition of the gas consists of:

CH_4 - 93%; C_2H_6-3.10%; C_3H_8-0.7%; C_4H_{10}-0.6%; CO_2-O.1%; N_2 - 2.5%; Total:100% The density of the gas is 0.771 kg / m3.

The total heat transfer of 1 m3 in this composition is 36,654 kJ / nm3. (at α = 1) - 9,634 m3 / m3 - excessive amount of air from the gas required for burning 1 m3. The amount of waste gases is 10 785 m3 / m3. When the excess air value is α = 1.205, the amount of air is 11.7 m3 / m3, and the amount of waste is 12,752 m3 / m3. The combustion temperature of a fuel is the amount of heat that is separated from the total fuel consumption of 1 kg or 1 Nm3 of gas. The amount of air required for combustion is determined by the theoretical amount of oxygen entering the reaction. In calculations, the air composition is as follows: nitrogen - 79%, oxygen - 21%. (When calculating the combustion of fuels in furnaces, the atmosphere is exposed to moisture) [2,3]

Let us consider the thermal models of the technological process.

Through the combustion process:

$$Q_{K1}; =Q^i_g * B, \qquad (1)$$

Q^i_g is the amount of heat that is released from the fuel with the ignition of 1 m3 of gas. B is hourly gas consumption, m3 / hour.

Physical heat of fuel:

$$Q_{K2} =B* C_h * t_h, \qquad (2)$$

C_h is the specific heat of the fuel, th is the temperature of the combustion process.

Heat input with raw materials:

$$Q_{K3}= G_{xa}*C_{xa}*t_{xa}, \qquad (3)$$

G_{xa} is the mass of the raw material, t_{xa} is the furnace temperature.

The amount of physical heat given by the air in the combustion process:

$$Q_{K4}= B* V_x * \alpha_1*t_x*C_x, \qquad (4)$$

V_x is theoretical air volume for burning 1 m3 of gas, t_x is air temperature during combustion, C_x is specific heat of air.

The physical heat of air in the furnace head due to the transfer of air due to the lack of a tight closure of the chamber of the furnace

$$Q_{K5} = B*V_x *(\alpha_2 -\alpha')* t_x*C_x, \qquad (5)$$

α is excessive amount of air. α' is considered as α = 1.4 / 1.5

The amount of physical heat brought into the furnace with secondary air.

$$Q_{K6}=B* V_в *(1.7-1.5)* t_x*C_x, \qquad (6)$$

V_B is the amount of waste gas.

Heat transfer equations:

$$Q_K= Q_{K1}+ Q_{K2}+ Q_{K3}+ Q_{K4}+ Q_{K5}+ Q_{K6} \qquad (7)$$

Consider methods for determining heat consumption in technological processes.

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Heat consumption for moisture extraction

$$Q_{C1} = P_k * G_{H2O} * 2499, \quad (8)$$

G_{H2O} is the amount of water discharged from the raw material when baking brick 1 kg. P_k is the production capacity of bricks, kg / h. The amount of thermal condensation in water converted to steam at 2499 ° C. KJ / kg;

Heat consumption in chemical reactions:

$$Q_{2.1} = P_k * G_{CaCO3} * 1587.6, \quad (9)$$

1587,6 is endothermic effect of the decoration of CaCO3. kJ / kg

$$G_{CaCO\,3} = \frac{CaCO\,3}{100} * Gr * CaCO3, \quad (10)$$

CaO is calcium in the soil contains 100 moles of $CaCO_3$, the oxide of CaCO is 56%.

Separation of MgCO3:

$$Q_{2.2} = P_k * G_{MgCO3} * 1318.8, \quad (11)$$

1318.8 is endothermic effect of MgC03 in decorative finishing. KJ / kg.

Dehydration of soil material:

$$Q_{2.3} = P_k * G_{H2O} * MgC0_3 * 6720, \quad (12)$$

6720 is endothermic effect of soil degradation, kJ / kg.

$$G_{H2O} = \frac{G_r^c * A}{100} - G_{Ca\,2}, \quad (13)$$

from this

$$G_{Ca2} = (G_{CaCO3} + G_{MgCO3}) - \left(\frac{CaO + MgO}{100}\right) * G_{cr}, \quad (14)$$

From thawing silicate mass:

$$Q_{2.4} = 315 * P_k, \quad (15)$$

315 is the amount of heat in the firing process of 1 kg of bricks during the transition of the mirror phase

Total heat consumption in the compartment for chemical reaction:

$$Q_{c2} = Q_{2.1} * Q_{2.2} * Q_{2.3} * Q_{2.4}, \quad (16)$$

Loss of heat due to the exit of the finished product from the furnace.

$$Q_{c3} = P_k * C_k * t_k, \quad (17)$$

t_k is the temperature of the brick at the moment of exit from the furnace. C_k is the specific heat of the baked brick

The amount of heat dissipated into the environment is 12% of the combustion temperature.

$$Q_{c4} = Q^i_g * 0.12 * B, \quad (18)$$

The amount of heat lost by the flue gas:

$$Q_{5.1} = B * V_x * C_{tg} * t_{tg}, \quad (19)$$

V_x is Volume of smoke consumed by the amount of ambient air (α ') per 1 cubic meter of gas. (V_x = 12.752 m3 / m3); C_{tg} - specific heat capacity of flue gas leaving the furnace.

The physical heat of water vapor through hygroscopic and chemical moisture:

$$Q_{5.2} = P_k * (G^x_{H2O} + G^k_{H2O}) G^{tg}_{H2O} * t_{tg}, \quad (20)$$

G^{tg}_{H2O} is Relative heat capacity of steam, which is taken in accordance with the temperature of the flue gas.

Physical heat:

$$Q_{5.3} = P_k * G^l_{or} * G^{tg}_{CH4} * t_{tg}, \quad (21)$$

G^l_{or} is the amount of heat released by volatile organic matter. G^{tg}_{CH4} is The heat capacity of methane is adopted depending on the temperature of the flue gas.

The amount of physical heat released by CO_2 during the decomposition of carbonates:

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$$Q_{5.4} = P_k * G_{CO2} * G^{tg}_{CO2} * t_{tg}, \quad (22)$$

G^{tg}_{CO2} is CO gas heat is measured by the temperature of the flue gas.

Total amount of heat lost by the flue gas:

$$Q_{c5} = Q_{5.1} * Q_{5.2} * Q_{5.3} * Q_{5.4}, \quad (23)$$

The amount of heat loss due to incomplete ignition of fuel:

$$Q_{c6} = x * B * Q^{i}_{g}, \quad (24)$$

x is fuel heat loss due to chemical non-ignition.
The equation of thermal energy for a one hour operation of a rotating brick oven:

$$Q_{к1}+Q_{к2}+Q_{к3}+Q_{к4}+Q_{к5}+Q_{к6}=Q_{c1}+Q_{c2}+Q_{c3}+Q_{c4}+Q_{c5}+Q_{c6}. \quad (25)$$

The amount of gas for the preparation of ceramic building material:

$$S_{gas} = \frac{B}{P_к}, \quad (26)$$

S_{gas} is the amount of gas for cooking 1 kg of ceramic building material. m3

$$R = S_{gas} * M * N, \quad (27)$$

R is the amount of gas for the preparation of all the ceramic building material in the furnace. N is total number of ceramic building materials in the furnace. M is the weight of the ceramic building material in the furnace.

III. CONCLUSION

Factors that make up the thermal model of the furnace for drying and baking bricks: analyzing the heat transfer and heat consumption equations, a model of thermal tempering was created during the hour-long operation of the furnace.

From here you can find gas consumption for an hour in an oven for baking ceramic building materials. Knowing the weight of the ceramic building material, using the instantaneous accuracy of gas consumption, a model was created that determines the amount of gas for the preparation of all ceramic building material in the oven.

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